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GENETIC EPISTEMOLOGY OF INTELLIGENT SYSTEMS: PROPOSITIONAL, PROCEDURAL, AND PERFORMATIVE INTELLIGENCE

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In a paper published in Systems Research, vol. 3, 1987[1], I wrote on interspecies cognitive intelligence that enabled humans and infrahumans to recognize, to be acquainted and appreciate other living beings, places and things. I argued that such intelligence was configural not notional.

The capacity for recognizing, being acquainted and appreciating is not additive or classificatory. Only those characteristics not shared by others are indexed.

Intelligent natural systems index the incomparable features of uniques. Such intelligence does not identify the particulars of a class, i. e., things of a kind, but discerns things that are of no kind. Thus, logical operations in recognition, acquaintance, or appreciation sort things that are of none other. Such operators do not negate. They index conspicuous features of perceived persons, places or things.

Employing Bremermann's Limit[2] that the absolute rate of data processing of all systems, natural or artificial, is 2 x 10^{27} bits/sec/gram mass, I claimed that the speed of data processing would not enable computers to match the perspica-

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cious discernment of intelligent natural systems. Empirical studies on pattern recognition confirmed a computer's lack of such configural intelligence.

In the sequel of that paper, I expressed my belief that there were additional interspecies links between intelligent natural systems. In this paper I shall suggest what such are and indicate the kinds of intelligence that are shared in artificially intelligent systems.

In a very perspicuous work, The Concept of Mind[3], Gilbert Ryle distinguished two kinds of knowing, 'knowing that' and 'knowing how'. 'Knowing that' was said to be a disposition to affirm or deny the adequacy of linguistic utterances naming concepts. 'Knowing that' is propositional. The canon for evaluating concepts is 'ordinary language'.

Ryle did not consider the syntactic, semantic and pragmatic states of propositions that index uniques. Possibly his focus on language rather than on signs was a factor leading toward such oversight. If one considers the structure, significance and functions of gestures, movements and ostensive utterances, 'knowing that' includes 'knowing that-one'. Ryle's 'knowing that' are propositions expressible only by language-using intelligent systems. Such users employ very abstract and inferential cognition. It is clear that humans use language. Claims that infrahumans, namely, apes use language is disputed, but the use of American sign language by them[4] has been used to counter claims of the exclusivity of human use of language. The arguments employed to establish that an apparent use of language by apes is a consequence of operant conditioning fail to make a case that the signing apes have achieved their cognitive skills solely through perceptual discrimination and reinforcement of wanted behavior. In order to communicate in signs or language the logical operator 'other' must be employed, for the communicator has to convey class differences as well as specific ones. Such logical operators as 'other' are not given in perceptual discrimination. Since the utililzation of logical operators is propositional, apes employing American sign language to communicate can be said to 'know that'.

Peter Geach, in his book Mental Acts[4], offers a cogent argument that perceptual discrimination is not an adequate description of the enactive process of sorting things. He uses an example of a child engaged in the task of sorting differently colored marbles mixed together in a jar. It is patent that in order to make the sort between the marbles, the child must be able to discriminate the various shades and hues of each color, but discrimination is insufficient for successful sorting. Geach points out that the sorting follows from an unvoiced use of 'other.' Something like the proposition, "This color is other than that color," is entailed. Following Geach's claim, one would accept that logical operators such as 'other' proceed communication. My reason for holding with Geach is that the same requirement is necessary for successful operant conditioning. Persons who shape behavior through contingencies of reinforcement seem not to consider that when they design their experiments they provide their subjects with "edges." Shaping discrimination cannot go forward if the subject has a continuum in view. In providing edges, behavioral controllers rely upon unvoiced enactively manifested classifications as prior conditions for shaping discriminative perception.

Both the controller and the subjects use logical operators such as 'same' and 'other'. With the operator, 'same', the logical connection that this <u>instance</u> is a member of this <u>kind</u> links the subject to the controller and the shaping goes forward.

Studies in animal behavior provide evidence that identification of an instance is a condition of infrahuman behavior. When a bird builds a nest, even at the same location, the materials put to use vary. The bird must identify that the blade of grass or twig is of that kind suitable for nest building.

Kohler's[5] apes identified boxes as those kind of things that could be used to provide access to food placed out of reach. A different identification allowed the apes to succeed in joining rods to extend their reach. Thus. there is no dichotomy splitting mentality in intelligent systems. In intelligent systems, 'knowing that-one' and 'knowing that' are shared.

In the view of some, my next remarks will take me farther " out on a limb" that is very close to a breaking point. Yet, there seems to be no adequate reason for excluding artificially intelligent systems as ones that know that instance.

Beside iteration, intelligent computers use the operator 'other' and 'same'. For example, in programs that help a user spell, a match is sought between the entered word and those in the computer's memory. Failing to locate one, it sorts until it finds a correct instance and, in sophisticated spelling checkers, automatically provides the correct spelling. Finding synonyms or supplying correct grammatical moves enables a computer to place before the user instances proper to the user's task. Since no program designer can forsee all the contingencies introduced by a user, the designer builds into the program the logical operators 'same' and 'other'.

Some discussion that followed the publication of Gilbert Ryle's, Concept of Mind, disputed his claim that 'knowing that ' and 'knowing how' were distinct cognitive intelligences. It was argued that one could not assert a proposition without being able to say the sentence that carried the embedded proposition. Without that doing there could be no proposition to assert.

This operational perspective on knowing guided persons devising 'programmed learnings' to direct learning tasks to doings. For example, Mager[6] argued that cognitive intelligence was represented by behavior. He held that behvioral objectives contained all meaningful (non-ambiguous) propositions. What Mager and others who agreed with him did not consider was the logical status of 'knowing that' and 'knowing how'.

In various writings, Israel Scheffler[7] demonstrated that the concept 'knowing that' had a different cognitive status than 'knowing how'. He noted that 'belief that' could be substituted in every sentence containing 'knowing that', but no such substitution was admissible for 'knowing how'. A substitution of 'belief that' for 'know that' did not violate linguistic use. It merely weakened the strength of the assertion. On the other hand, substitution of 'belief how' was never in accordance with common use. Knowing how to do something does not entail belief.

Such arguments, that vindicate claims that 'knowing how' and 'knowing that' are distinct kinds of cognition, establish that performances are cognitive as well as psychomotor activities. It seems patent that 'knowing how' names a kind of intelligence employed in action, but what kind of intelligence is it?

Ryle argued that 'knowing how' did not name habitual actions. It named the use of critical judgment while acting within a particular situation. For example, driving an automobile in traffic is no mere application of habituated actions. To avoid coming to grief, a driver must respond to conditions of traffic flow and to anticipate conditions on the road ahead.

Although Scheffler and others presented logical and conceptual refinements on Ryle's characterization of 'knowing how', these refinements did not go far enough. A condition for deciding whether one observed a performance or a happening was not included. For example, a non-swimmer might manage to keep his head above water, yet an observer could question that that person knows how to swim. In addition to having the capacity and the facilities for swimming, the person must perform as a swimmer does. Of course a non-swimmer does not perform. He beats the water. If he is lucky, he stays afloat. What ever happens is an accident. It is not a controlled activity.

The missing condition for specifying that one knows how is a dynamic one that marks the timing of actions in a doing.

F. C. S. Bartlett[8] identified that condition. In his studies of skill acquisition, he observed that the movements of a novice were oscillatory. As the skill was mastered, a learner developed timing so that the oscillations were reduced and the actions flowed continuously. In other words, a performer's actions are smoothly connected. The actions of a non-performer lack such flow. The smoothness condition in 'knowing how' not only distinguishes 'knowing how' from 'happened to be', it distinguishes a procedure (a way of doing) from a performance (a doing). It is evident that one can know a procedure for doing something without being able to do it. In that case no dynamic condition is relevant.

There are other reasons for distinguishing between a procedure and a performance. In an article in which D. G. Brown[9] commented on Ryle's explication of 'knowing how', he introduced the concept 'knowing that what'. Through structural analysis of the grammatical use of the term 'knowing how', Brown disclosed an ambiguity in Ryle's use of 'knowing how'. He demonstrated that 'knowing how' was used in two different senses and Ryle did not consider these differences.

Brown noted that the standard use of 'knowing how' denotes someone's doing something such that the evidence for the doing is in the actual doing. Brown used the example of a person walking about in a canoe. The walking is the evidence of the knowing. If one knows how to walk about in a canoe, he does not tip the canoe off center. Stabililty is maintained. If one does not know how to walk about in a canoe, the canoe will lose stability and the walker might get wet.

In the English use of the term 'knowing how' one has 'know how'. When one has 'know how', one knows what to do and when to do it. Such knowing is not revealed in the activity , but in the results of the activity. Brown used the example of a builder of a frame house. Since there is more than one way to build a frame house, an observer has only the result, the completed house, as evidence that the builder knows how to build one. The standard use of 'knowing how' names a performance and the English use of 'knowing how' names a procedure. Brown referred to procedural knowing as quasi-propositional for the knowing was not a performance.

By following Bartlett and Brown, two kinds of knowing how can be explicated, performative and procedural. 'Procedural knowing' is that kind of knowing that prescribes how something is to be done. It lays out the constitutive elements and specifies the sequence of actions of a doing, for example, a recipe.

'Performative knowing' actualizes a doing. For example, to follow a recipe a cook must convert the procedures enactively. Such conversion does not follow as a matter of course. Not all cooks are good ones. Some know what to do, but can not execute what they know to do.

'Procedural knowing' and 'performative knowing' can be more or less complex, As doings, they are single pathed (e.g. a nondestructive opening of a combination lock) or multipathed (e.g. taking an alternate highway to a destination).

Most doings in human behavior are multipathed, but favored paths usually take precedence over others. I call such performances 'conventional' because single or non-branching pathways are not essential for the doing. When conventional performances are made part of a tradition they become protocolic (single pathed and necessary).

When conventional performances are individualized they manifest a style of doing. For example, Toscanini's and Bruno Walter's conduction of a symphony orchestra were not the same doings even though these conductors directed orchestras that were sounding the same symphony.

I shall now consider the extent to which procedural and performative intelligence is exhibited in intelligent systems. No one can seriously hold that humans and infrahumans do not know how to do something. No mechanical explanation can account for the plasticity of their performances. Even claims that certain behavior is instinctual cannot be supported by a cogent argument that such behavior is 'blind', i.e., not a knowing. With blind behavior no adaptation could occur. Environmental change would always result in a catastrophy. Fortunately for a species, DNA-RNA messages imprinted in an organism are never specific; they are particular. They allow a common generality in the messages so that behavioral change is possible.

The example that I like of such 'instinctive' particularity is in a story that I read in grade school. As the story goes, the Scottish king, Robert Bruce, was defeated by enemy forces six times in succession. While in retreat, King Bruce took refuge in a rude shack. While resting, Bruce saw a spider trying to bridge a gap between two beams. The spider did not succeed in connecting the beams with a thread of webbing until the seventh try.

If such trying were determined specifically, the spider could never succeed. The thread had to be lengthened after each try. The spider's behavior was adaptive, not reactive.

The seventh try not only inspired Bruce to try again to defeat his enemy--the story reported that on that try King Bruce succeeded--it enabled the spider to stay alive.

That happening does not establish that the spider knew how to bridge the gap. Unfortunately, Robert Bruce did not engage in controlled observation. He did not disconnect the thread in order to observe the smoothness of the spider's renewed actions in bridging the gap. Nevertheless, it is a fact that once a spider constructs a web it smoothly repairs it.

A stronger case can be made that infrahumans know how to perform by describing the behavior of vertebrate animals. For centuries humans have domesticated or trained animals to execute complex non-native performances.

I vividly recall a sway-backed horse assigned to pull a milk wagon. In addition to pulling the wagon, that horse stopped at a customer's house farther up the street so that the milkman did not have to return to the wagon until his bottle carrier was empty of filled bottles. The horse's performance was smooth and efficient. It knew how to execute the requirements in the milk route. The horse's performance, however, was protocolic, for when a customer moved, the horse had to be taught to by-pass the house of that former customer.

It seems that when animals are trained to perform, the performance is usually protocolic. As in closed societes, alternative pathways are not permitted. The trainer, like a tyrant, requires subordinates to act according to his rule.

In the wild, the matter is different. A wild animal suffers no such restrictions regarding alternative pathways.

A predator, for example, selects terrain and orchestrates movement in order to optimize concealment. The lay of the land and the location of prey are variables utilized in selecting pathways during the hunt.

When animals communicate with each other they enactively specify procedures. For example, the apes in Japan[10], who teach their young to separate rice from sand by washing the mixture at the shallow shore, use 'hands on' methods to lay out the specifics of the performance. The adult apes demonstrate and the young apes practice until they succeed. The elders 'coach' the young in their washing.

When humans coach, demonstration is usually an addendum to description. The demonstration is intended to control the manner of the performance.

Some non-linguistic communicators, such as apes, use demonstration. Most animals follow exemplifications to grasp the procedures for a performance.

Again I shall report from my witnessing, but what I shall report merely reflects what is well established by research on animal behavior.

We live in an "A" frame house located in a heavily wooded uneven terrain. The inclination is so steep that the front of the house is at street level and the deck at the back of the house is 15 feet above the ground.

Fifteen years ago we acquired a cat we named "Coral." During that time we could confine her outdoor activities to the deck. Feral cats live in the woods. It is not unusual for these once domesticated cats to seek inclusion by signing for entrance at our doorstep. One day we gave shelter to such a cat whom we called "Ra."

We placed him on the deck. In a few hours, Ra solved the problem of access to the ground. He walked along the rain gutter from the deck to the front of the house. Seeing Ra's performance, Coral, at first, hesitatively and then smoothly, walked along the same path.

Ra left us for other places. Some months later another feral cat came to our door. Seeing Coral walk to the ground, he quickly made his way to the deck in an effort to gain access to us. This cat not only learned what to do, he grasped the procedure as symmetrical. It was identical both ways.

Intelligent computers are programmed to follow procedures and, like Coral, they learn procedures through exemplification. When computers are designed to interact with learners, they engage the learner through description, demonstration and exemplification.

At Indiana University, I was taught how to write Chinese characters. Following a procedure of what to do, I made marks on a koala pad in order to copy a character displayed on the monitor. The computer evaluated my moves, informed me of my errors and demonstrated the correct sequence and direction of the strokes needed to write that character. After that demonstration, a properly formed character appeared beside the one that I had written as an exemplar to follow on my next try. Given such displays, it seems evident that both procedural and performative 'knowing how' are distributed in intelligent computers as well as in intelligent natural systems.

There are two additional kinds of procedural knowing that can be explicated, but, by me, cannot be shown to be distributed beyond human systems. They are innovation and creation. Although I can explicate the logical conditions of both, I cannot satisfy my belief that such procedures are distributed in other intelligent systems.

Innovation is a kind of procedural or performative knowing that transforms paths or elements of paths from one kind of doing to another related doing. Improvisation in music or technical modifications of inventions are examples of innovation. Kohler's apes seemed innovative in devising ways to reach food, but the evidence for such is inconclusive. The joining of poles or stacking of boxes could have been an accident like Goodyear's discovery of the way to vulcanize rubber.

Creation can be explicated as the development of new procedures for performance. Creative procedures do not reconstruct previous ones. They lay out new ways to perform. Powered flight exemplifies creation.

Unlike earlier attempts to build flying machines, the Wright Brothers[11] did not adapt bird-like movements or wing structures. They used wind tunnel experiments to develop an effective wing, motor and propeller. The result was a vehicle that did not fly like a bird, but one that flew like an airplane. Manpowered flight, on the other hand, is an innovation. Both the procedures and principles for powered flight were adapted to provide that alternative way for humans to fly. It now seems possible to power such machines by having animals run on treadmills. With powered flight such an innovation has little practical significance. As with manpowered flight, it would provide an interesting engineering challenge, however.

Since I came so far out on my limb of conjecture, one might expect me to attempt an argument that links innovation and creation in intelligent natural systems. With respect to such an attempt, I shall borrow a line from Brain who in his book, <u>Mind, Perception and Science</u>,[11] cited the line from a poem written by Yeats:

"Horseman pass me by!"

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George Maccia's Epistemology of Educational Objectives

This is a copy of a handout from Maccia, not part of the paper itself, but gives a nice summary of his epistemology and tutorial conditions for knowing.

Symbols: S = student
T = teacher
Q = object of knowing
P = performance or action

Tutorial Conditions of Knowing That

Qualitative Knowing:

RECOGNITION: S recognizes Q iff

1. S believes that Q.
2. S is completely justified in believing that Q.
3. No other statement or belief defeats S's belief that Q.
4. S selects Q from not Q and not Q from Q.
5. Q is a state of affairs.
6. T knows that the above conditions hold in order that S recognize Q.

ACQUAINTANCE: S is acquainted with Q iff

1. S recognizes Q.
2. S selects elements $[q_1 \ldots q_j]$ determinate of Q; and relations $[r_1 \ldots r_j]$ determinate of Q.
3. Q is a state of affairs.
4. T knows that the above conditions hold in order that S be acquainted with Q.

APPRECIATION: S appreciates that Q iff

1. S is acquainted with Q.
2. S selects elements $[q_1 \ldots q_j]$ appropriate of Q; and relations $[r_1 \ldots r_j]$ appropriate of Q.
3. Q is a state of affairs.
4. T knows that the above conditions hold in order that S appreciate that Q.

Quantitative Knowing

INSTANTIATION: S identifies Q iff

1. S believes that Q.
2. S identifies Q as an instance of a kind.
3. S correctly believes Q.
4. Q is a state of affairs.
5. T knows that the above conditions hold in order that S identify Q.

THEORETICAL KNOWING: S knows the theory of that Q iff

1. S believes that Q.
2. S is in a position to know that Q.
3. S correctly believes that Q.
4. S presents an evidentiary argument that completely justifies S's belief that Q.
5. S explicates the relevance and fruitfulness of the theory of that Q.
6. Q is a state of affairs.
7. T knows that the above conditions hold in order that S knows the theory of that Q.

CRITERIAL KNOWING: S knows the criteria of that Q iff

1. S believes that Q.
2. S is in a position to know that Q.
3. S correctly believes that Q.
4. S presents a justificatory argument to establish the credibility of criteria of that Q.
5. S demonstrates the relevancy and fruitfulness of criteria of that Q.
6. Q is a state of affairs.
7. T knows that the above conditions hold in order that S knows the criteria of that Q.

Tutorial Conditions of Knowing How

Procedural Knowing

PROTOCOLIC PROCEDURES: S knows the protocol of P iff

1. S iterates the constituents and succession of movements in executing the protocol.
2. The protocol is the way of performing P.
3. P is a single pathed doing.
4. T knows that the above conditions hold in order that S knows the protocol for doing P.

CONVENTIONAL PROCEDURES: S knows the convention of Q iff

1. S iterates the preferred constituents and succession of movements in executing Q.
2. The convention is a way of performing Q.
3. Q is a multi-pathed doing.
4. T knows that the above conditions hold in order that S knows the convention for doing Q.

Performative Knowing

PROTOCOLIC PERFORMANCE: S knows how to do the protocol P iff

1. S has the capacity for doing P.
2. S has the facility for doing P.
3. S smoothly executes P.
4. P is a single pathed doing.
5. T knows that the above conditions hold for doing P.

CONVENTIONAL PERFORMANCE: S knows how to do the convention P iff

1. S has the capacity for doing P.
2. S has the facility for doing P.
3. S smoothly executes P.
4. P is a multi-pathed doing.
5. T knows that the above conditions hold for doing P.

Non-Tutorial Knowing How

Innovation: S knows how to innovate the doing of P iff

1. S has the capacity for doing P.
2. S has the facility for doing P.
3. S smoothly executes constituents and succession of movements into some performance P_n when P includes P_n, and P_n is not equivalent to P.
4. P is a doing.

Creation: S knows how to create the doing P iff

1. S has the capacity for doing P.
2. S has the facility for doing P.
3. S smoothly executes constituents and succession of movements of P(1, 2, ... n) into P_2 where P(1, 2, ... n) are elements of P and P_2 is not included in P.
4. P is a doing.